Paper ID: 100677
student

23rd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 23rd IAA SYMPOSIUM ON SPACE DEBRIS (IP)

Author: Mr. Karanpreet Raja
York University, Canada

Ms. Adrianna Karistinos
York University, Canada
Mr. Joaquin Philco
York University, Canada
Mr. Gurpreet Singh
University of Waterloo, Canada
Dr. Vitali Braun
IMS Space Consultancy, Germany
Dr. Jean-Pierre Hickey
University of Waterloo, Canada

MULTISPECTRAL SENSOR FUSION FOR ENHANCED DETECTION AND TRACKING OF RESIDENT SPACE OBJECTS

Abstract

As the number of satellites and space debris in orbit increases, the accurate detection and tracking of Resident Space Objects (RSOs) have become critical topics of discussion. Multispectral imaging offers transformative advantages for RSO detection and tracking by enhancing visualization, revealing spatial correlations, and enabling classification based on unique spectral patterns. The feasibility of applying multispectral imaging to RSOs will be evaluated through SOBER, an atmospheric balloon experiment equipped with a lower-resolution infrared (IR) camera and a higher-resolution panchromatic camera. An atmospheric balloon allows for clearer observations compared to ground-based telescopes by reducing atmospheric distortion while also being eco-friendly, as it avoids pollution and space debris contributions. The payload is designed to capture RSOs under challenging conditions such as straylight intrusion, low light, and high-contrast environments. This work proposes a method for fusing images from different spectral bands to reduce noise, mitigate obstructions, and enable consistent cross-correlation between sensor captures. Firstly, image registration techniques will be used to align and stack images, reducing noise and enhancing the visibility of faint RSOs that may be undetectable in a single capture or mistakenly classified as noise. Bright stars are used as reference points for alignment, while multi-scale keypoint detection extracts structural features from optical images to establish correspondences with IR captures; addressing the lack of consistent textures and high contrast edges in the IR data. Once features are identified, affine transformations or homography are applied for precise alignment. Following alignment, image normalization will harmonize intensity scales across spectral bands. This process uses global normalization to standardize brightness and contrast levels, local normalization to emphasize fine details and mitigate localized exposure issues, spectral balancing to calibrate the relative contributions of each spectral band, and haze correction to reduce sunlight-induced scattering effects. A Contrastive Correspondence Network (CCN) will then be employed to bridge the resolution gaps between the visible-spectrum and IR images. This superresolution task is a crucial step in preparing the multispectral images for RSO detection models, as it sharpens object boundaries and preserves important features in the lower-resolution IR images; improving detection and tracking accuracy. This work contributes to advancing Space Situational Awareness (SSA) by refining multispectral processing techniques for improved RSO tracking under

varying conditions.